

The invention provides a process, catalyst and apparatus for carrying out the water-gas shift reaction comprising employing a low-pyrophoricity water-gas shift reaction catalyst; wherein the low-pyrophoricity water-gas shift reaction catalyst comprises a solid high heat capacity particulate support impregnated with: (i) a reducible metal oxide and (ii) a catalytic agent.

[illegible]

UNITED STATES PATENT AND TRADEMARK OFFICE  
DOCUMENT CLASSIFICATION BARCODE SHEET

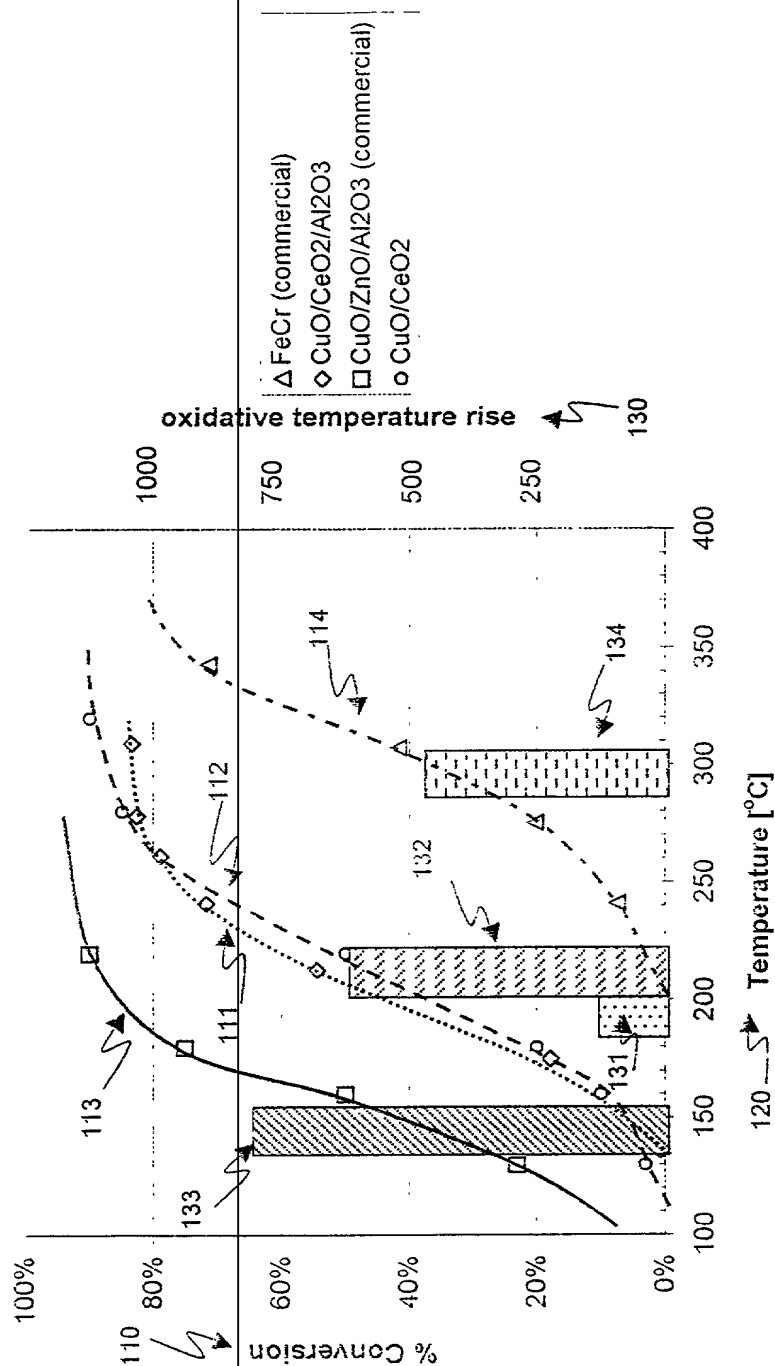


**Drawings**

**7**

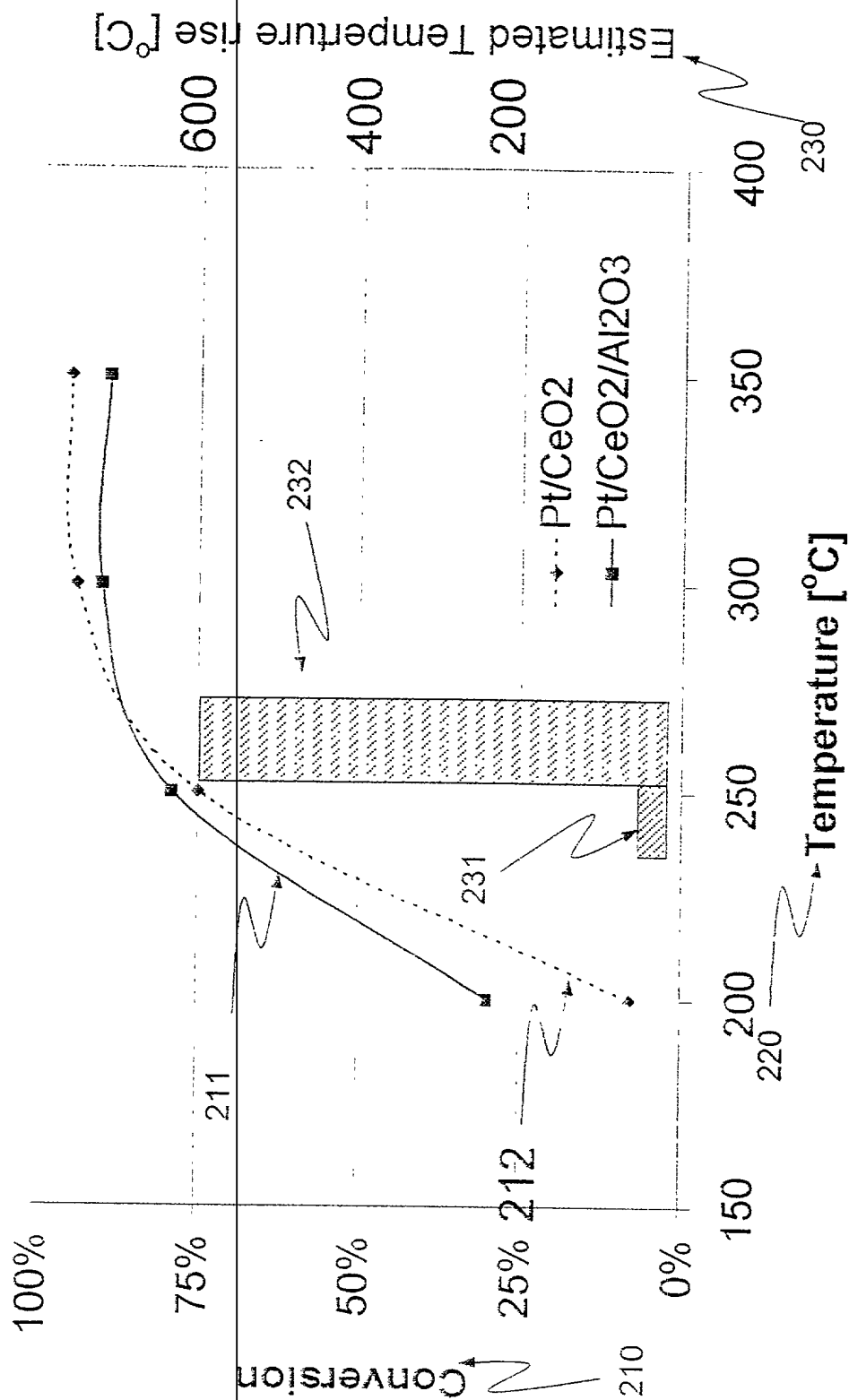
Figure 1

Activities (lines) and pyrophoricity (columns) of  
 $\text{FeCr}$ ,  $\text{CuO/ZnO/Al}_2\text{O}_3$ ,  $\text{CuO/CeO}_2$  and  $\text{CuO/CeO}_2/\text{Al}_2\text{O}_3$   
 2%  $\text{CO}$ , 10%  $\text{H}_2\text{O}$ , 20%  $\text{H}_2$ , 5%  $\text{CO}_2$ ; VHSV = 5,000  $\text{h}^{-1}$



# Comparison of activity (lines) and pyrophoricity (columns) of Pt/CeO<sub>2</sub> and Pt/CeO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> catalysts

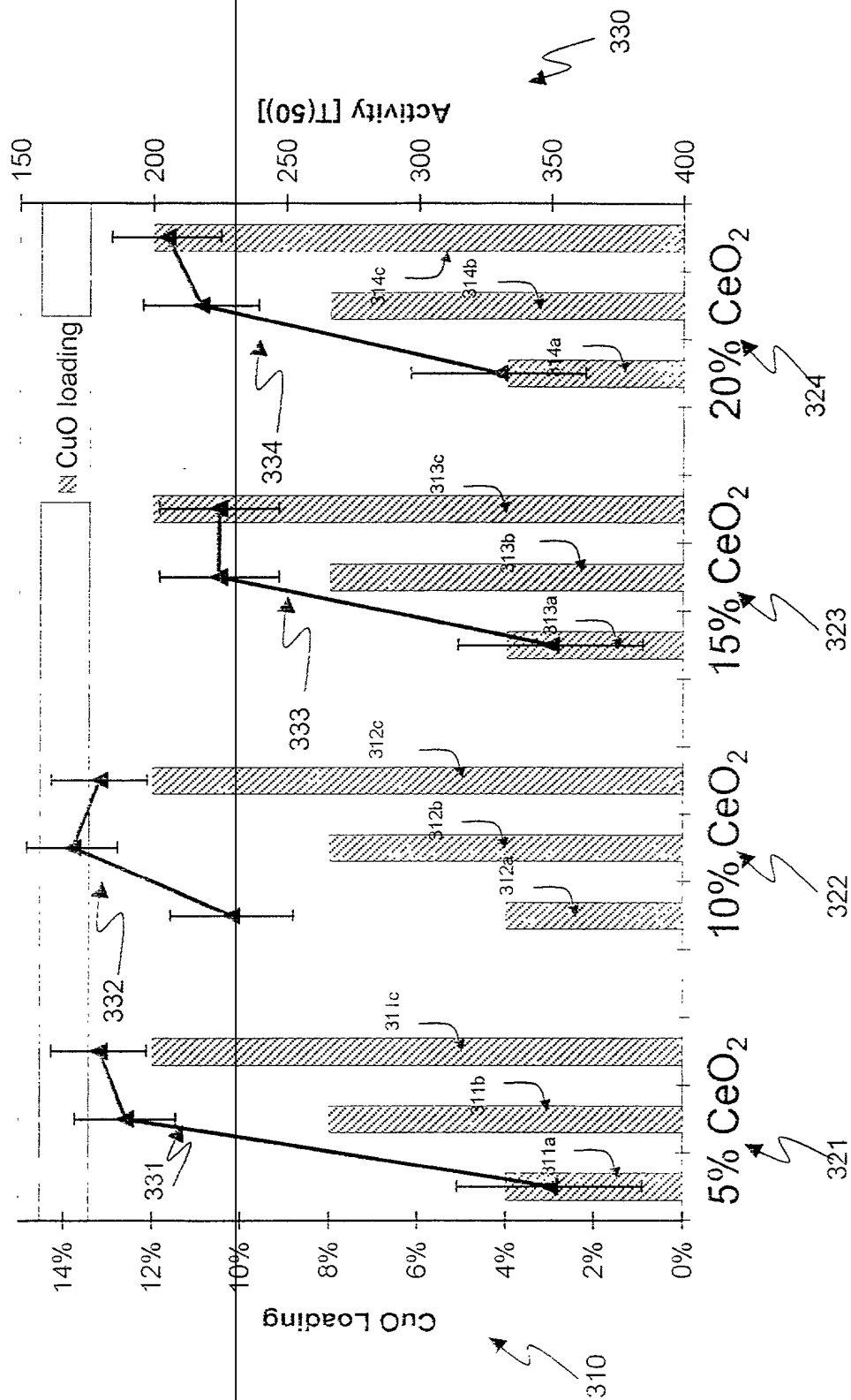
0.5% CO, 20% H<sub>2</sub>, +10% H<sub>2</sub>O, WHSV=24,000 h<sup>-1</sup>



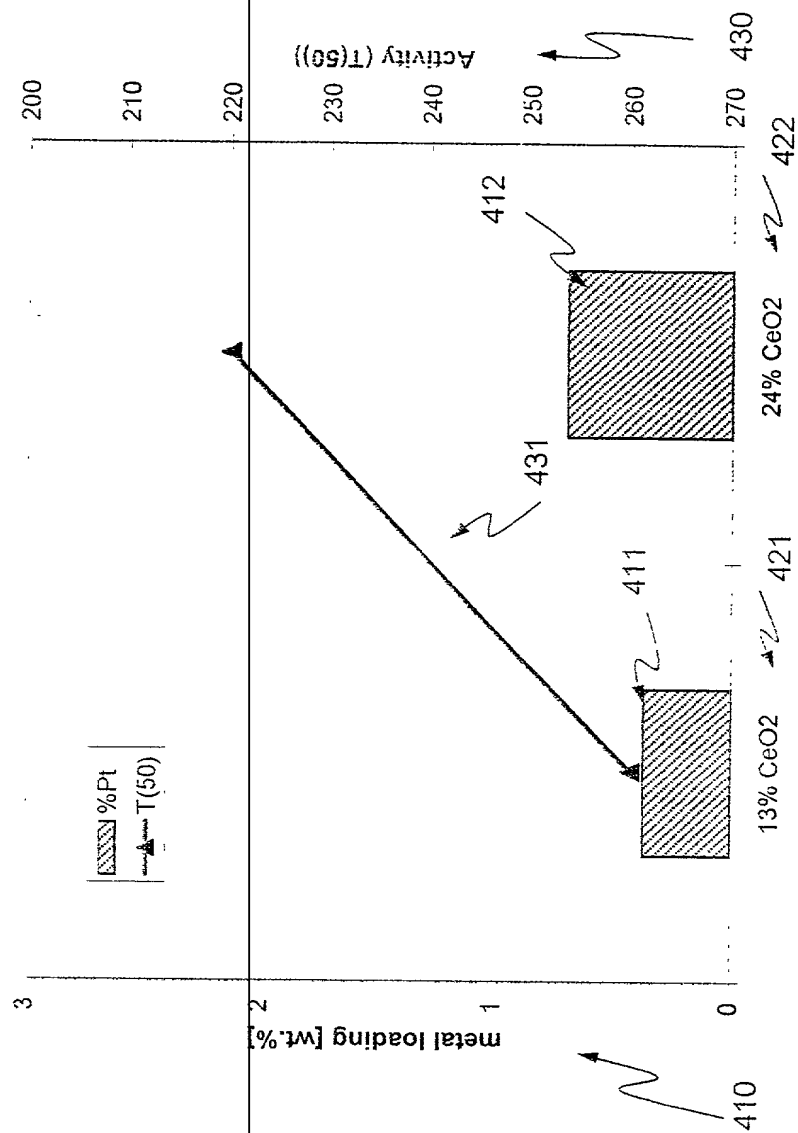
# Dependence of WGS activity on Ce- and Cu-loading

(18,846-29+38, samples WR-66,75, exp. WR-67,76,78)

test conditions: 2% CO, 20% H<sub>2</sub>, +10% H<sub>2</sub>O balance N<sub>2</sub> WHSV = 30,000 h<sup>-1</sup>

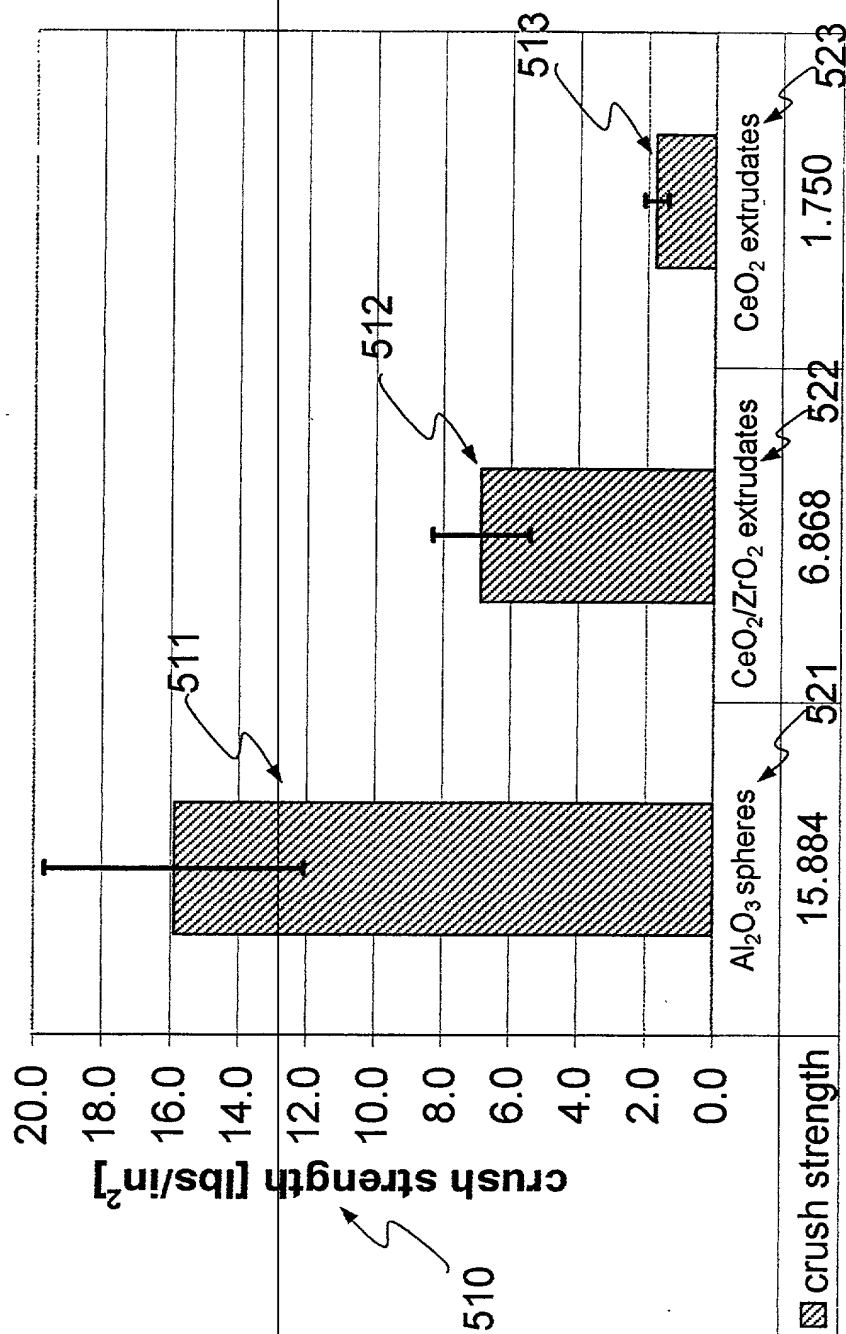


Effect of Ce and Pt loading on the activity of Pt/CeO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> catalysts  
0.5% CO, 20% H<sub>2</sub>, +10% H<sub>2</sub>O, WHSV=24,000 h<sup>-1</sup>



# Crush strength of catalyst support particles

## Average and standard deviation of 20 samples



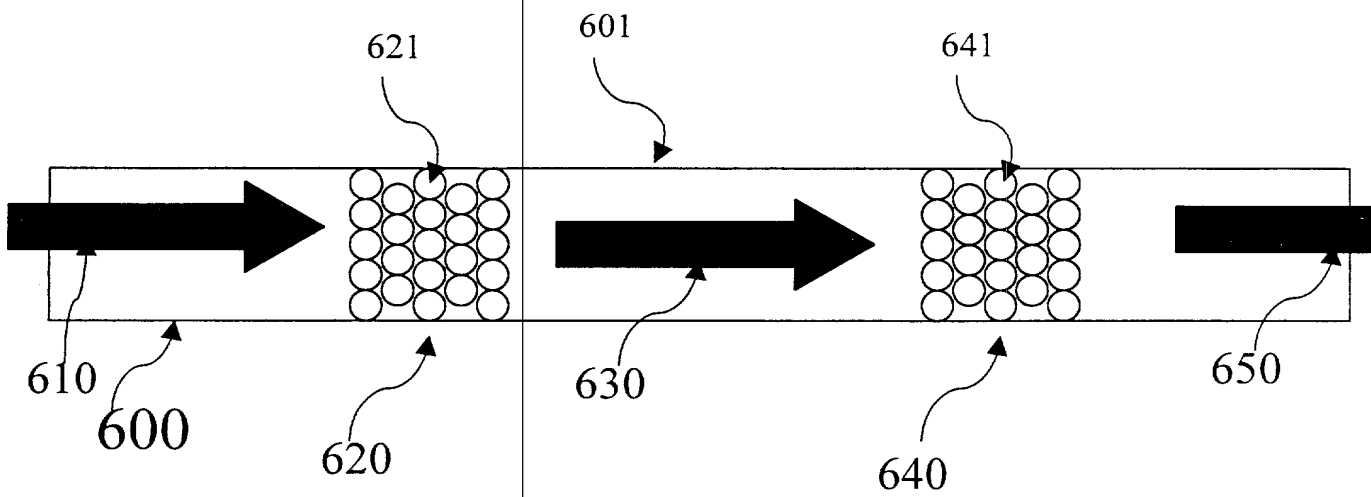
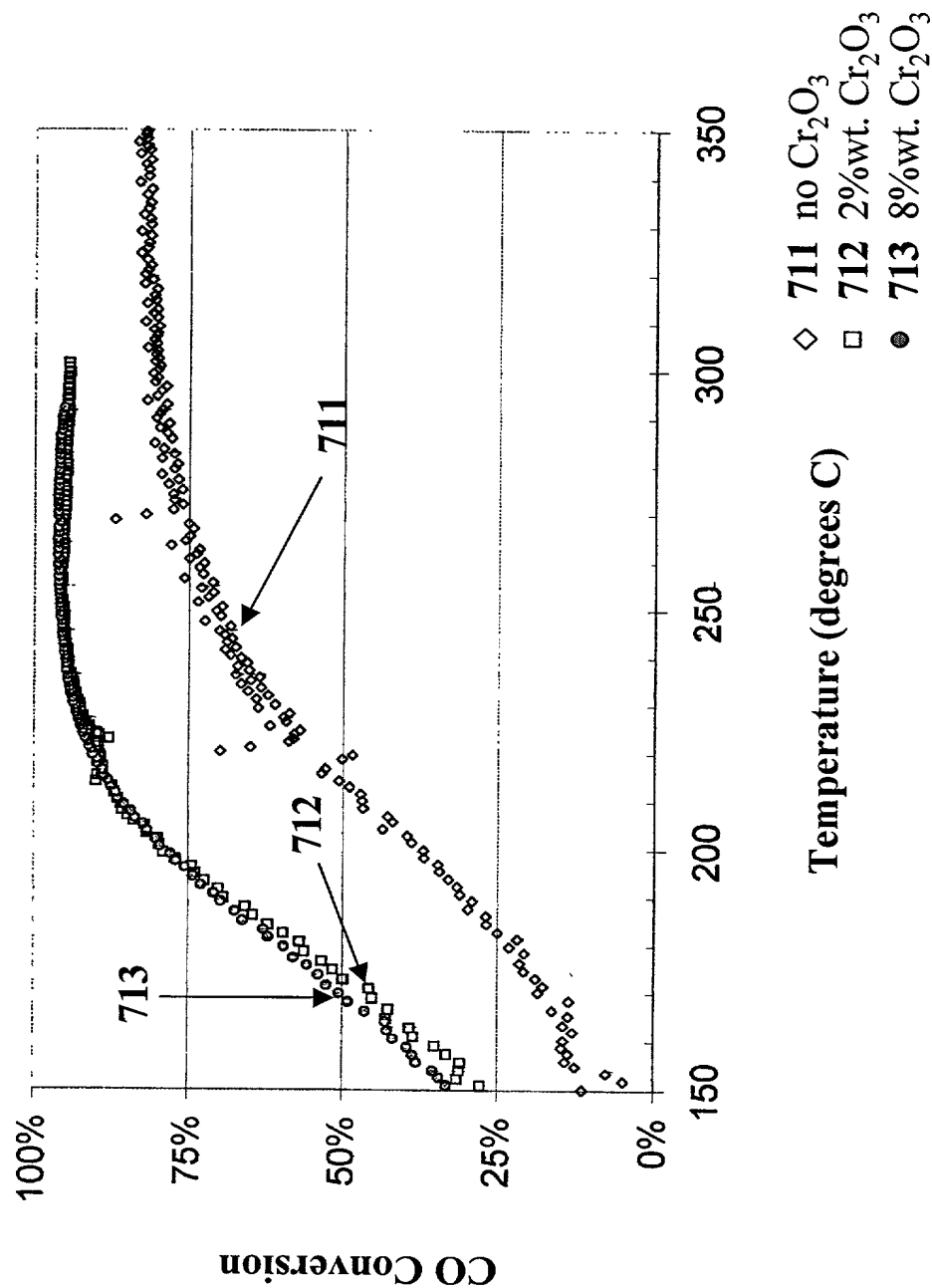


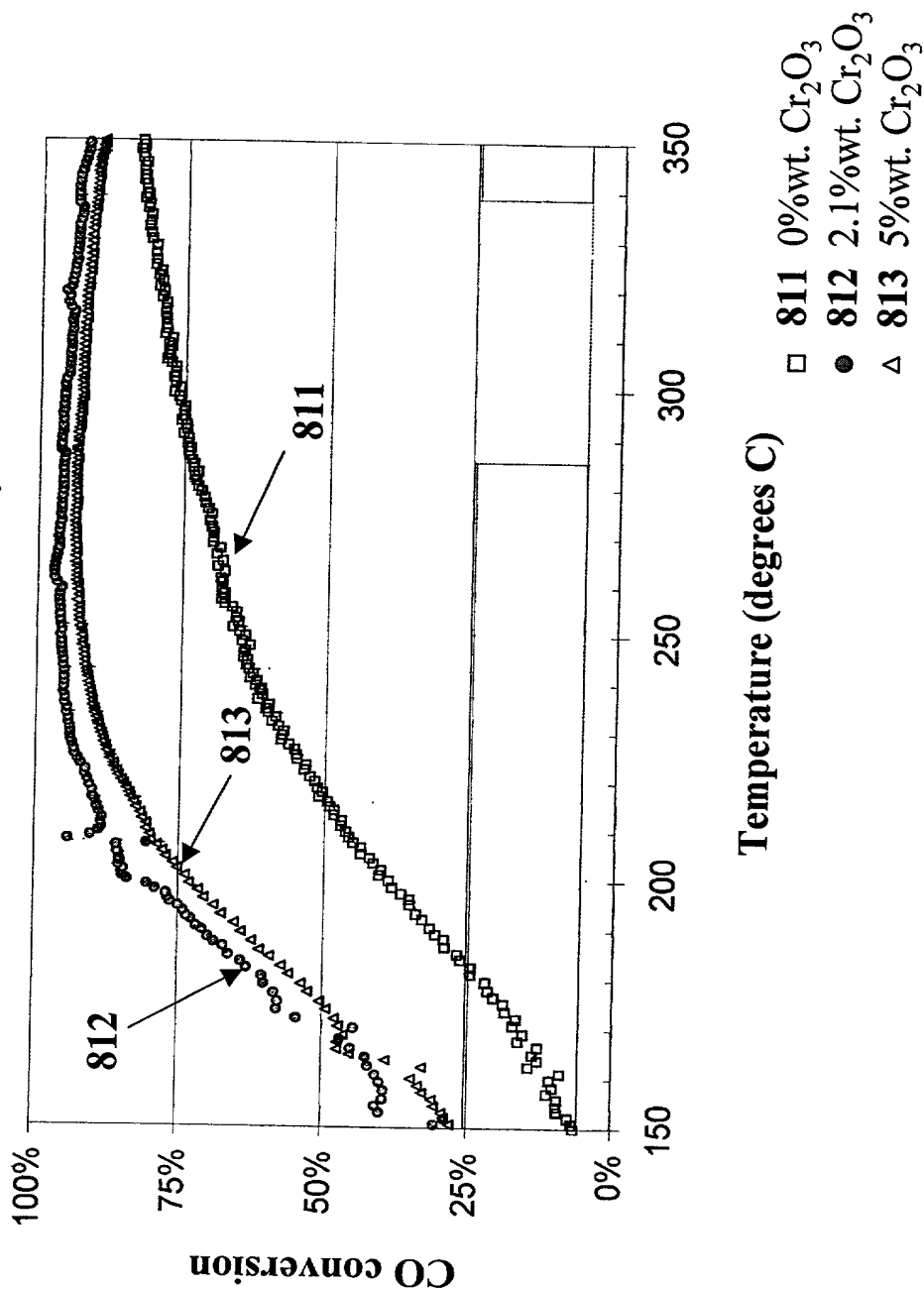
FIG. 6



**Figure 7:** Effect of  $\text{Cr}_2\text{O}_3$  Level on the Catalytic Activity of  $\text{CuO}/\text{Al}_2\text{O}_3$  WGS Reaction Catalysts



**Figure 8:** Effect of  $\text{Cr}_2\text{O}_3$  Level on the Catalytic Activity of  $\text{CuO}/\text{CeO}_2/\text{Al}_2\text{O}_3$  WGS Reaction Catalysts



**Figure 9:** Effect of the Sequence of Synthetic Steps on the Catalytic Activity of  $\text{CuO/Cr}_2\text{O}_3/\text{CeO}_2/\text{Al}_2\text{O}_3$  WGS Reaction Catalysts

